such as rate control function of a value or a button press. Different regions and borders between regions can be associated with different haptic sensations.

[0011] An embodiment advantageously provides haptic feedback to a planar touch control device of a computer, such as a touchpad or touch screen. The haptic feedback can assist and inform the user of interactions and events within a graphical user interface or other environment and ease cursor targeting tasks. Furthermore, an embodiment allows portable computer devices having such touch controls to take advantage of existing haptic feedback enabled software. The haptic touch devices disclosed herein are also inexpensive, compact and consume low power, allowing them to be easily incorporated into a wide variety of portable and desktop computers and electronic devices.

[0012] These and other advantages will become apparent to those skilled in the art upon a reading of the following specification and a study of the several figures of the drawing.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] FIG. 1 is a perspective view of a haptic touchpad;

[0014] FIG. 2 is a perspective view of a remote control device including the touchpad;

[0015] FIG. 3 is a perspective view of a first embodiment of the touchpad including one or more actuators coupled to the underside of the touchpad;

[0016] FIG. 4 is a side elevational view of a first embodiment in which a piezo-electric actuator is directly coupled to the touchpad;

[0017] FIG. 5 is a side elevational view of a second embodiment of the touchpad including a linear actuator;

[0018] FIG. 6 is a side elevational view of a third embodiment of the touchpad having an inertial mass;

[0019] FIG. 7 is a top plan view of an example of a touchpad having different control regions; and

[0020] FIGS. 8a and 8b are top plan and side cross sectional views, respectively, of a touch screen embodiment.

DETAILED DESCRIPTION

[0021] FIG. 1 is a perspective view of a portable computer 10 including a haptic touchpad. Computer 10 is preferably a portable or "laptop" computer that can be carried or otherwise transported by the user and may be powered by batteries or other portable energy source in addition to other more stationary power sources. Computer 10 preferably runs one or more host application programs with which a user is interacting via peripherals.

[0022] Computer 10 may include the various input and output devices as shown, including a display device 12 for outputting graphical images to the user, a keyboard 14 for providing character or toggle input from the user to the computer, and a touchpad 16. Display device 12 can be any of a variety of types of display devices; flat-panel displays are most common on portable computers. Display device 12 can display a graphical environment 18 based on application programs and/or operating systems that are running, such as a graphical user interface (GUI), that can include a cursor 20

that can be moved by user input, as well as windows 22, icons 24, and other graphical objects well known in GUI environments. Other devices may also be incorporated or coupled to the computer 10, such as storage devices (hard disk drive, DVD-ROM drive, etc.), network server or clients, game controllers, etc. In alternate embodiments, the computer 10 can take a wide variety of forms, including computing devices that rest on a tabletop or other surface, stand-up arcade game machines, other portable devices or devices worn on the person, handheld or used with a single hand of the user, etc. For example, host computer 10 can be a video game console, personal computer, workstation, a television "set top box" or a "network computer", or other computing or electronic device.

[0023] Touchpad device 16 preferably appears externally to be similar to the touchpads of the prior art. Pad 16 includes a planar, rectangular smooth surface that can be positioned below the keyboard 14 on the housing of the computer 10, as shown, or may be positioned at other areas of the housing. When the user operates the computer 10, the user may conveniently place a fingertip or other object on the touchpad 16 and move the fingertip to correspondingly move cursor 20 in the graphical environment 18.

[0024] In operation, the touchpad 16 inputs coordinate data to the main microprocessor(s) of the computer 10 based on the sensed location of an object on (or near) the touchpad. As with many touchpads of the prior art, touchpad 16 can be capacitive, resistive, or use a different type of sensing. Some existing touchpad embodiments are disclosed, for example, in U.S. Pat. No. 5,521,336 and U.S. Pat. No. 5,943,044. Capacitive touchpads typically sense the location of an object on or near the surface of the touchpad based on capacitive coupling between capacitors in the touchpad and the object. Resistive touchpads are typically pressure-sensitive, detecting the pressure of a finger, stylus, or other object against the pad, where the pressure causes conductive layers, traces, switches, etc. in the pad to electrically connect. Some resistive or other types of touchpads can detect the amount of pressure applied by the user and can use the degree of pressure for proportional or variable input to the computer 10. Resistive touchpads typically are at least partially deformable, so that when a pressure is applied to a particular location, the conductors at that location are brought into electrical contact. Such deformability can be useful since it can potentially amplify the magnitude of output forces such as pulses or vibrations on the touchpad. Forces can be amplified if a tuned compliant suspension is provided between an actuator and the object that is moved, as described in U.S. Pat. No. 6,680,729. Capacitive touchpads and other types of touchpads that do not require significant contact pressure may be better suited in many embodiments, since excessive pressure on the touchpad may in some cases interfere with the motion of the touchpad for haptic feedback. Other types of sensing technologies can also be used in the touchpad. Herein, the term "touchpad" preferably includes the surface of the touchpad 16 as well as any sensing apparatus included in the touchpad unit.

[0025] Touchpad 16 preferably operates similarly to existing touchpads, where the speed of the fingertip on the touchpad correlates to the distance that the cursor is moved in the graphical environment. For example, if the user moves his or her finger quickly across the pad, the cursor is moved a greater distance than if the user moves the fingertip more